REMARKS

1. Claims 1, 2 and 4-17 are pending, and of those 7-9 and 14-17 stand withdrawn due to not being elected in response to a restriction requirement.

2. Claims 2, 4, 10 and 13 stand rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

3. Claims 1,2,4-6, and 10-13 stand rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 6,221,260 to Chahine et al. in view of "Effect of Shrinking Microbubble on Gas Hydrate Formation", Takahashi et al.

4. Claims 2, 4, 10 and 13 have been amended. Claims 7-9 and 14-17 have been cancelled. No new matter has been added.

5. Rejections Under 35 U.S.C. 112, second paragraph

Claims 2, 4, 10 and 13 stand rejected under 35 U.S.C 112, second paragraph, as being allegedly indefinite for failing to particularly point out and distinctly claim the subject matter which the applicant regards as the invention.

Claims 2, 4, 10 and 13 have been amended and Applicant submits this rejection is now moot.

6. Rejections Under 35 U.S.C. 103(a)

Claims 1,2,4-6, and 10-13 stand rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 6,221,260 to Chahine et al. in view of "Effect of Shrinking Microbubble on Gas Hydrate Formation", Takahashi et al.

Applicant submits that U.S. Patent No. 6,221,260 ("Chahine") teaches a method belonging to the well-known hydrodynamic cavitation technology. In the hydrodynamic cavitation technology described in "Chahine", tiny bubbles are generated as the phenomenon of boiling caused by the reduction of pressure due to a hydrodynamic mechanism. When pressure returns to the origin, these bubbles spontaneously collapse because the interior gas characteristically consists of water moisture.

In the technology taught by Chahine, the important point is that the moisture is a condensable gas and the volume of the bubble rapidly decreases owing to the phase change from gas to liquid. The interior gas is compressed by the effect of the surface tension according to the Young-Laplace equation, and during the time period of collapsing the interior pressure rapidly increases inversely proportional to the bubble size. In the case of moisture bubbles, the collapsing speed is very fast and the bubble temperature rapidly increases owing to the adiabatic compression. Also, the high temperature region, a hot spot, generates the free radicals by decomposing the interior moisture and/or the surrounding water.

Applicants submit that while Chahine is concerned with bubbles that have an interior gas that characteristically consists of water moisture, the present invention targets tiny bubbles that have interior gases such as air, ozone, and oxygen as the main contents of the bubble. Since these gases are not condensed, the bubble doesn't collapse easily even if the ambient pressure is increased. Thus, the present invention regards a technical method to collapse the tiny bubbles having interior gases such as air, ozone, and oxygen as the main contents of the bubble, and bubbles that are less than 50 μm in diameter.

The manuscript of "*J. Phys. Chem. B*, **2003,** *107,* 2171-2173. ("Takahashi") " has demonstrated that the fundamental property of tiny bubbles can be used as the method of gas hydrate generation because of their ability to make the conditions of hydrate nucleation milder

due to the increasing interior gas pressure while decreasing in size under water. The interior gas reacts with the surrounding water under the existence of the nuclei and generates the hydrate particles. There is no teaching in Takahashi of generating free radicals, because the shrinking speed of the tiny bubble in Takahashi is not fast enough to generate free radicals.

Thus, Applicants submit that the method of the present invention would not be derived by the person skilled in the art in view of "Chahine" and "Takahashi ".

In particular, Applicant has carefully reviewed the references with particular attention to the passages cited by the Examiner and can find no teaching in Chahine or Takahashi of: "A method for collapsing microbubbles, the microbubbles having a diameter of 50 μm or less and floating in a solution and decreasing gradually in size by natural dissolution of the gas contained in the microbubbles, the method comprising accelerating a speed of microbubble size decrease and disappearance by applying a stimulation to the microbubbles, *wherein a great amount of free radical species are released from a gas-liquid interface by increasing a charge density at the gas-liquid interface of the microbubbles*", as recited in claim 1.

The Examiner states that Chahine teaches a method of producing a microbubble using a swirling fluid cavitating jet and in which a stimulation is provided to cause the rapid collapse of the bubble. The Examiner then states that Chahine is different from claim 1 in that Chahine does not mention whether bubbles of less than 50 μm are produced. Applicant agrees on this point.

The Examiner then states that Takahashi teaches the creation of microbubbles using a swirling fluid microbubble generator to produce microbubbles with a diameter distribution which includes microbubbles having a diameter of 50 μm or less and cites FIGs. 1 and 2 of Takahashi.

Takahashi is concerned with a fundamental property of tiny bubbles that can be used in a method of gas hydrate generation. This property is the ability of tiny bubbles to make the conditions of hydrate nucleation milder due to increasing interior gas pressure while decreasing in size under water. The interior gas reacts with the surrounding water under the existence of the nuclei and generates the hydrate particles.

Applicant respectfully submits even though Takahashi generates microbubbles having a diameter of 50 μm or less, that Takahashi is not concerned with accelerating the speed of microbubble collapse and therefore does not teach or suggest: "the microbubbles having a diameter of 50 μm or less and floating in a solution and decreasing gradually in size by natural dissolution of the gas contained in the microbubbles, the method comprising *accelerating a speed of microbubble size decrease and disappearance by applying a stimulation to the microbubbles"*, as recited in claim 1.

Further, as is evident in FIG. 1, Takahashi teaches introducing a gas (Xe) into the chamber to create the microbubbles.

By contrast, Chahine is concerned with a technique belonging to the well-known hydrodynamic cavitation technology. In the hydrodynamic cavitation technology described in "Chahine", tiny bubbles are generated by the phenomenon of boiling caused by a reduction of pressure due to a hydrodynamic mechanism. When pressure returns to the origin, these bubbles spontaneously collapse because the bubble interior gas characteristically consists primarily of liquid vapor. In Chahine the liquid vapor in the bubbles is a condensable gas and the volume of the bubbles rapidly decrease upon a phase change from the gas (liquid vapor) back to the liquid. One common liquid taught by Chahine is water, with the gas in the bubbles being water vapor. Thus, the Chahine is concerned with bubbles that have a condensable interior gas that undergoes and can undergo a phase change from gas to the surrounding liquid when collapsing.

By contrast the microbubbles in Takahashi are of a different gas (Xe) than the liquid (distilled water in Takahashi FIG. 1). Thus, the microbubbles in Takahashi have an interior gas that is not condensable and an interior gas that cannot undergo a phase change to the surrounding liquid when collapsing.

Thus, Applicant submits that it would not be obvious to a person skilled in the art to combine the techniques taught in Chahine to the microbubbles of Takahashi.

Also Applicant submits that there is no teaching in Takahashi or in Chahine of "the microbubbles having a diameter of 50 μm or less … *wherein a great amount of free radical species*

are released from a gas-liquid interface by increasing a charge density at the gas-liquid interface of the microbubbles", as recited in claim 1.

Therefore, Applicant submits that Chahine and Takahashi taken singly or in combination do not teach, suggest, motivate or make obvious claim 1 and thus claim 1 is patentable in view of Chahine and Takahashi.

Claims 10 and 13

In the Office Action the Examiner states that Chahine contemplates producing cavitation within a nozzle chamber, and then expelling the cavitation pockets out of the nozzle chamber in an annulus of axially flowing liquid (See e.g. Fig. 5 and col. 12 lines 30-45), and that Chahine goes on to explain that the cavitation nozzles are placed within a cavitation chamber which is connected to a recirculation pipe and pump (See Figs. 8 and 9 and col. 13 line 56 -- col. 14 line 40). The Examiner states that Chahine further provides plates, or walls, for causing the collapse of the bubbles (Chahine col. 13 lines 35-40), and further specifies that the plates or walls contain orifices (See Chahine col. 13 lines 40-42). But, the Examiner states that Chahine does not specifically mention having the plate w/ orifices installed in the circulation pipe.

The Examiner states that, nonetheless, Chahine explains that when the swirling vortex with cavitation pockets is sheathed in an annulus of axially flowing liquid, that placement of the collapse inducing surface can be placed farther away from the nozzle outlet in order to extend the time in which cavitation is present while still advantageously causing violent collapse of the cavitation pockets (See Chahine col. 13 lines 50-56). Therefore, it would have been obvious to a person having ordinary skill in the art at the time of invention to place the collapse inducing surface in the recirculation pipe downstream of the nozzle exit in order to increase the time in which cavitation is present, while still producing violent bubble collapse.

The Examiner makes similar contentions regarding claim 13.

Applicants respectfully disagree. Chahine in col. 13, lines 22-42 states:

"Next, at step 104 the swirling liquid within the chamber is ejected through an exit orifice aligned on the longitudinal axis of the chamber. In this manner, the *cavitation pockets formed in the central vortex are also injected through the exit orifice and may be directed towards a wall or surface spaced to create a short gap between the nozzle and the surface*. The exiting swirling fluid jets stagnate within this gap, increasing ambient pressure in that region. The changing pressure initiating the asymmetric collapse of the cavitation bubble. One portion of the bubble wall begins to dimple, and the pressure differences create a microjet, or reentrant jet, which accelerates collapse of the bubble. The microject travels through and impinges on the opposite wall of the collapsing bubble, resulting in a collapse with a violent force that may be advantageously used for water purification as described above. It will be appreciated that the geometry of the surface is not critical to the invention and that it may be substituted with *plates or walls of other geometry, provided that it is in sufficient proximity to the swirling jet nozzles to enhance the cavitation* as described above. The *surface may contain orifices to control the pressure in the gap*." (emphasis added)

Applicants submit forming bubbles in a nozzle and then shooting them at a wall with or without orifices, cannot be compared to "accelerating a speed of microbubble size decrease and disappearance by applying a stimulation to the microbubbles, wherein a great amount of free radical species are released from a gas-liquid interface by increasing a charge density at the gas-liquid interface of the microbubbles… wherein the stimulation is *compression, expansion and swirling current generated by circulating part of a microbubble-containing solution in a container connected by a circulation pipe to a circulation pump and making the solution path through an orifice plate or porous plate having a single hole or multiple holes, wherein the orifice plate or porous plate is installed in the circulation pipe"*, as recited in claims 1 and 10 and similarly in claim 13.

Applicant submits Chahine teaches away from claim 10 by teaching that "the geometry of the surface is not critical to the invention and that it may be substituted with plates or walls of other geometry, *provided that it is in sufficient proximity to the swirling jet nozzles to enhance the cavitation"*. The nozzle in Chahine creates the bubbles. Therefore a person skilled in the art

would be led to locate a wall with or without orifices close to whatever generates the bubbles. Applicant submits that therefore Chahine teaches away from claims 10 and 13.

In contrast, Claim 1 recites "*a microbubble-containing solution in a container*", and a "*circulation pump*" that circulates the "*microbubble-containing solution*" through a *"circulation pipe…* and an *"orifice plate or porous plate having a single hole or multiple holes….. installed in the circulation pipe"*. The Applicant submits that the container does not create the bubbles in contrast to the nozzle of Chahine. Rather the container of claim 1 just contains the "*microbubble-containing solution*".

Further, Applicant submits that it would not be obvious to a person skilled in the art in view of Chahine to install a wall with orifices inside a circulation pipe. There is no teaching or suggestion of a wall inside a pipe in Chahine.

Therefore, Applicant submits that Chahine and Takahashi taken singly or in combination do not teach, suggest, motivate or make obvious claims 10 and 13 and therefore claims 10 and 13 are patentable in view of Chahine and Takahashi.

Dependent Claims

Remarks concerning dependent claims 10 and 13 are above. Claims 2, 4-6 and 10-13 depend on claim 1. "If an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious." *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988). Therefore, in light of the above discussion, Applicant submits that claims 2, 4-6 and 10-13 are also allowable at least by virtue of their dependency on nonobvious claims as well as the additional limitations recited by each of these claims.

In view of the above, Applicant submits that the application is now in condition for allowance and respectfully urges the Examiner to pass this case to issue.

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The Commissioner is authorized to charge any additional fees which may be required or credit overpayment to deposit account no. 12-0415. In particular, if this response is not timely filed, the Commissioner is authorized to treat this response as including a petition to extend the time period pursuant to 37 CFR 1.136(a) requesting an extension of time of the number of months necessary to make this response timely filed and the petition fee due in connection therewith may be charged to deposit account no. 12-0415.

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